TEGAM INC.

MODEL DSRS-5DA
DECADE SYNCO/RESOLVER STANDARD

Instruction Manual
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REV. A

NOTE: This user's manual was as current as possible when this product was manufactured. However, products are constantly being updated and improved. Because of this, some differences may occur between the description in this manual and the product received.

Warranty:

TEGAM, Inc. warrants this product to be free from defects in material and workmanship for a period of 1 year from the date of shipment. During this warranty period, if a product proves to be defective, TEGAM, Inc., at its option, will either repair the defective product without charge for parts and labor, or exchange any product that proves to be defective.

TEGAM, Inc. warrants the calibration of this product for a period of 1 year from date of shipment. During this period, TEGAM, Inc. will recalibrate any product, which does not conform to the published accuracy specifications.

In order to exercise this warranty, TEGAM, Inc., must be notified of the defective product before the expiration of the warranty period. The customer shall be responsible for packaging and shipping the product to the designated TEGAM service center with shipping charges prepaid. TEGAM Inc. shall pay for the return of the product to the customer if the shipment is to a location within the country in which the TEGAM service center is located. The customer shall be responsible for paying all shipping, duties, taxes, and additional costs if the product is transported to any other locations. Repaired products are warranted for the remaining balance of the original warranty, or 90 days, whichever period is longer.

Warranty Limitations:

The TEGAM, Inc. warranty does not apply to defects resulting from unauthorized modification or misuse of the product or any part. This warranty does not apply to fuses, batteries, or damage to the instrument caused by battery leakage.

Statement of Calibration:

This instrument has been inspected and tested in accordance with specifications published by TEGAM, Inc. The accuracy and calibration of this instrument are traceable to the National Institute of Standards and Technology through equipment, which is calibrated at planned intervals by comparison to certified standards maintained in the laboratories of TEGAM, Inc.

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SECTION I
GENERAL DESCRIPTION

1.1 PURPOSE

The Model DSRS combines the functions of a decade synchro standard and a decade resolver standard into a single unit. A front panel switch changes the unit from one mode to another.

The standard may be used to simulate a master component in a system. Accurately known inputs may be introduced into the system for testing autopilots, servos, aircraft indicators, etc. This technique can also be used to check the response of a servo loop.

As a synchro standard, the unit may be used to transmit precise angular data to control differential transmitters (CDX's) and control transformers (CT's) (see Figure 1-2) . Most commercially available synchros of this type may be excited without affecting the 2-second-of-arc accuracy. The unit may also be used to excite torque differential transmitters (TDX's), differential receivers (TDR's), and receivers (TR's).

As a resolver standard, the unit may be used to transmit precise angular data to resolver control differential transmitters (RD's) and resolver control transformers (RC's). As with the synchro mode, most commercially available resolvers may be excited without affecting the 2-second-of-arc accuracy.

When the Model DSRS is used for testing components, either the Proportional Voltage Gradient or the Proportional Voltage Nulling method may be used. If the Proportional Voltage Nulling method is used, the Model DSRS may be adjusted

to obtain a null instead of the dividing head. In this case, the angular error may be read directly from setting of the control switches.

1.2 GENERAL DESCRIPTION

Because of their very low output impedance and extremely low output impedance unbalance, the standards may be operated under normal load with no degradation of accuracy. The angular accuracy is based on the use of toroidal transformers and therefore age or environmental conditions have little effect.

The following features are incorporated in the unit:

a. 100° increment switching to simulate operation over a full 360°.
b. Separate sets of binding posts for the synchro and resolving outputs.
c. Selectable output (E_S max).
d. Excitation of 115 or 26 vac.

1.2.1 Resolver Mode

The unit forms a precision transformer instrument, designed to simulate the ideal electrical outputs of a resolver control transmitter (RX). Each section transforms an input signal to two isolated voltages: one of the output voltages is proportional to the sine of the angle displayed on the dials and the other is proportional to the cosine.

1.2.2 Synchro Mode

In the synchro mode, the four wire output is converted to a three wire output in a Scott-tee transformer arrangement. The unit simulates the ideal 3-wire electrical output of a synchro control transmitter (CX). One of the three voltages is directly proportional to the sine of the angle displayed on the dials and the other two voltages are located 120° in amplitude from the first.

1.2.3 Specifications

Refer to Table 1-1 for the Model DSRS-5DA specifications.

Table 1-1. MODEL DSRS-5DA SPECIFICATIONS

Angular Range .... 0° to 360° continuous

Angular Accuracy....................................... 2 seconds-of-arc at nominal frequency

Angular Increments .... 0.0001°

Excitation:

Voltage .... 115 or 26 vac

Frequency....................................... 400 to 800 Hz

Output, E_S (MAX)....................................... 115, 90, 26, and 11.8 volts

Maximum Effective Output
Impedance Unbalance:

115 and 90 volts .... 0.05 + j.005 ohms

26 and 11.8 volts .... 0.01 + j.001 ohms

Dimensions:

Bench Operation:

17" wide

5 7/8" high (including feet)

16 7/8" deep (including handles)

Rack Mounted:

15 1/8" deep from back of ears to end of back panel terminals

19" wide

5 1/4" high

Weight: 33 Ibs

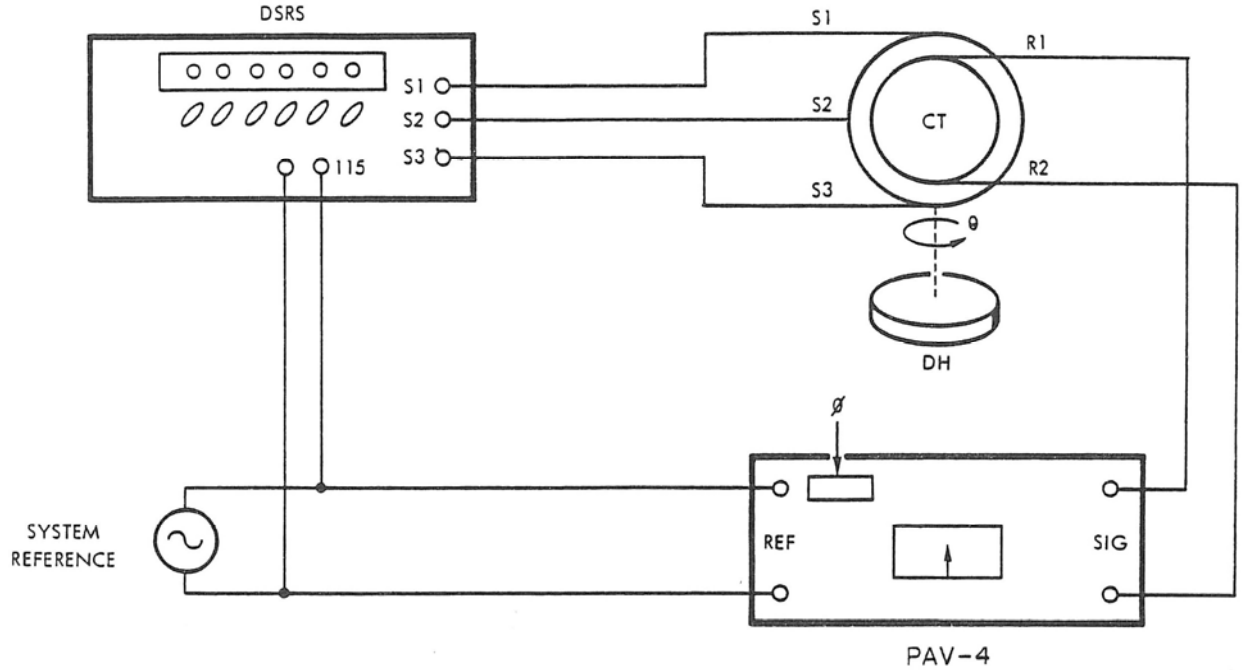


Figure 1-2. Typical Test Setup, Synchro Mode

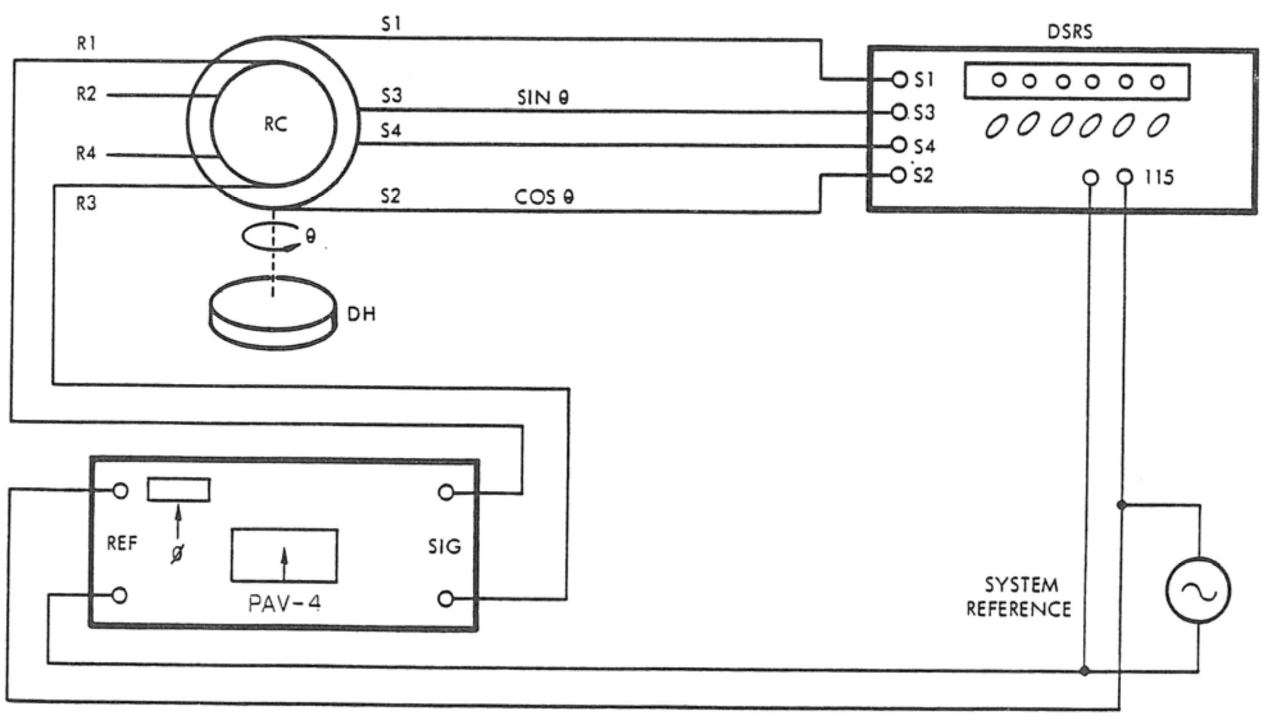


Figure 1-3 Typical Test Setup, Resolver Mode

SECTION II
INSTALLATION

2.1 UNPACKING

No special handling or unpacking procedures are required. After unpacking, inspect units for any evidence of damage.

2.2 BENCH OPERATION

The DSRS-5DA is shipped ready for use as a bench-operated instrument. A folding support that is attached to the feet under the front of the instrument may be pulled down to elevate the front of the instrument for ease of operation'.

2.3 RACK MOUNTING

A set of adapter brackets and attaching screws (Option 11) -permits mounting of the DSRS-5DA into a standard 19-inch rack. To prepare the instrument for rack mounting, proceed as follows:

a. Remove the six screws that attach the four feet and folding support to the bottom of the instrument. Retain the screws, feet and support for future use.

b. Attach rack mount kit (Part No. OPT-11) using hardware provided.

2.4 OPERATING POWER

No operating power is required; however, either 115 or 26 vac excitation voltage is required during operation.

2.5 INSTALLATION CHECKOUT

Refer to paragraphs 5.4 through 5.7 for a checkout procedure.

SECTION III
OPERATION

3.1 GENERAL

3.1.1 Synchro Binding Posts

The color coding of the synchro binding posts and the phase relations of the output voltage relative to input voltages conform to the requirements of Military Specification MIL-S-20708. To convert the terminal identifications to the Aeronautical Radio, Inc. (ARINC) system, refer to Table 3-1. The conversions given in the table apply for 0 degree index reference and positive rotation reference.

3.1.2 Resolver Binding Posts

The color coding of the resolver binding posts and the phase relations of the output voltage relative to input voltages conform to the requirements of Military Specification MIL-R-21530.

TABLE 3-1 BINDING POST IDENTIFICATIONS, SYNCHRO MODE

COLOR CODE	IDENTIFICATION	ARINC SYSTEM
Red	R1	H
Black	R2	C
Blue	S1	X
Black	S2	Z
Yellow	S3	Y
White	Case Gnd	

3.2 SPECIAL PRECAUTIONS

To obtain maximum accuracy, observe the following precautions:

a. Always use high quality switches, with very low contact resistance, whenever it is necessary to switch the outputs.

b. Never fuse the outputs.

c. Do not purposely apply an unbalanced load.
d. Use No. 18 tinned copper wire from the output of the standard to the load and attempt to keep the total lead length from each output pin the same.
e. Stator current should be limited to approximately one ampere for normal switch contact life and should never exceed two amperes.

3.3 OPERATION

To operate the standard, proceed as follows:

a. Set E_S (MAX) OUTPUT switch to desired maximum output voltage.
b. Set TYPE switch to appropriate position.
c. Connect system or unit under test to the appropriate set of OUTPUT binding posts.
d. Connect excitation voltage to the appropriate INPUT binding posts.

CAUTION

Do not apply 115 V to the 26 V INPUT binding post.

e. Set in the desired angle with the decade control switches.

SECTION IV
THEORY OF OPERATION

4.1 RESOLVER MODE

The electrical position of a resolver transmitter can be determined from the ratio of the two output voltages to each other. One of the output voltages is proportional to the sine of the rotational angle and the second is proportional to the cosine. At 0° , the sine voltage is 0 and the cosine voltage is maximum. At 45° , the two voltages are equal and approach a 0.707 ratio to the maximum output voltage.

In the Model DSRS, a transformer is placed across the input voltage and functions as a dual voltage divider. The dual secondaries of the transformer are tapped to provide the voltage ratios of an ideal resolver at 10° increments. One secondary provides a voltage proportional to the sine of the selected angle and the second is proportional to the cosine.

The increased resolution of the decade increments is provided by two ratio transformers, see Figure 4-1. Both ratio transformers are controlled by a common set of switches. Transformers T3, T5 and T7 provide the additional increments for the sine voltage and all sine voltage increments are added together to form the output voltage. Transformers T4, T6 and T8 provide the additional cosine increments and these increments are subtracted from the voltage supplied by transformer T2.

The cosine voltage, selected by contacts B and C of switch S2, supplies not only the 10° cosine increment but also supplies the input for the primary of transformer T3. The secondary of transformer T3 is tapped to provide voltage divisions corresponding to the tangents of the 1° increments. Contact A of switch S3 selects a COS X TAN voltage. In the example shown, this voltage

is a COS 40° X TAN 5° product. The total voltage at contact A is the sum of the voltage selected by contact D of switch S2 (SIN 40°) plus the COS 40° X TAN 5° product. This total voltage may also be expressed as:

$$\frac{\text{SIN } (40° + 5°)}{\text{COS } 5°}$$

The two arms of switch S3 (A and B) supply a 1° sine voltage to transformer T5. This transformer is tapped to approximate the .1° sine increments. Contact A of switch S4 therefore selects a .1° sine voltage which is added to the voltage supplied from contact A of switch S3. The addition process continues until the final .001° is selected by switch S6.

The cosine voltage is developed in approximately the same manner. Since the sine voltage input to transformer T4 is inverted, the voltages selected from the cosine ratio transformers are subtracted. In the example shown, the voltage of contact C of switch S3 is equal to COS 40° - SIN 40° X TAN 5°. This total voltage may also be expressed as:

$$\frac{\text{COS } (40° + 5°)}{\text{COS } 5°}$$

The voltage ratios repeat every 90° ; however, the mathematical signs of the ratios (+ or -) change for each quadrant. Switch S1 changes the signs by inverting the voltages.

Transformer Tl in the input circuit performs two functions; first it operates as an autotransformer to step-up a 26 volt input and second it corrects for variations in transformation ratio. In the method used to derive the sine and cosine voltages, the transformation ratio varies over any 10° increment. The input voltage is varied by a separate arm of switch S3 to compensate for this variation.

In the resolver mode, transformers T9 and T10 operate as step-down transformers to allow formers to allow selection of the maximum output voltages E_S (MAX). This selection is accomplished through switch S7.

4.2 SYNCHRO MODE

The electrical position of a synchro control transmitter (CX) can be determined from the ratio of the stator output voltages to each other. As shown in Figure 4-2, each of the three output voltages is a sine function.

The sine θ voltage, as derived in the resolver mode, is also used as the sine θ voltage for the synchro mode. To derive the other output voltages, transformers T9 and T10 are interconnected into a Scott tee arrangement as shown in Figure 4-3. The sine and cosine inputs to the transformers are derived in the same manner as for the resolver mode.

4.3 DIRECT READOUT

For a direct readout of angular position, the quadrant switch is replaced with a 100° increment switch as shown in Figure 4-4.

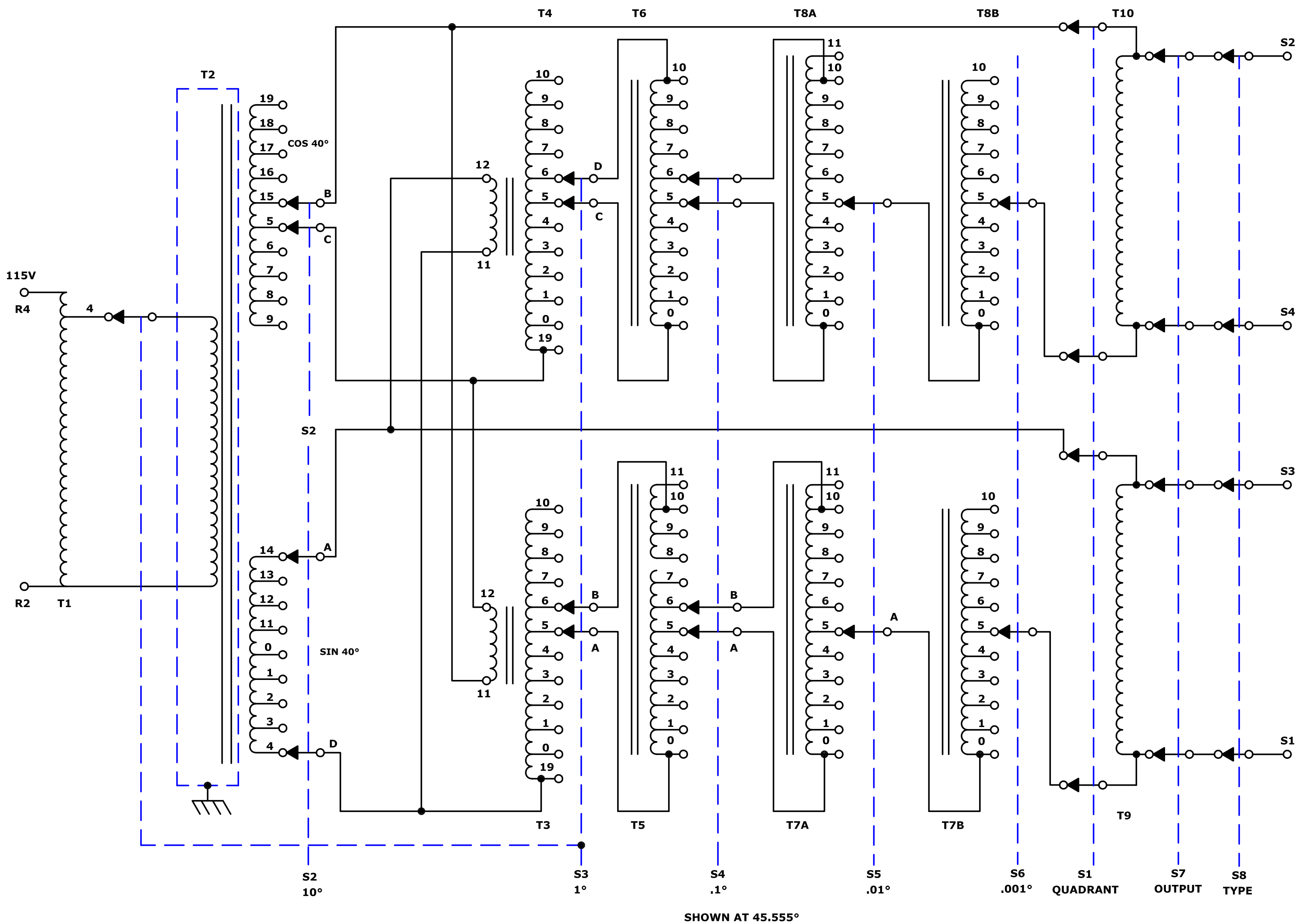


Figure 4-1. Resolver Mode, Simplified Diagram

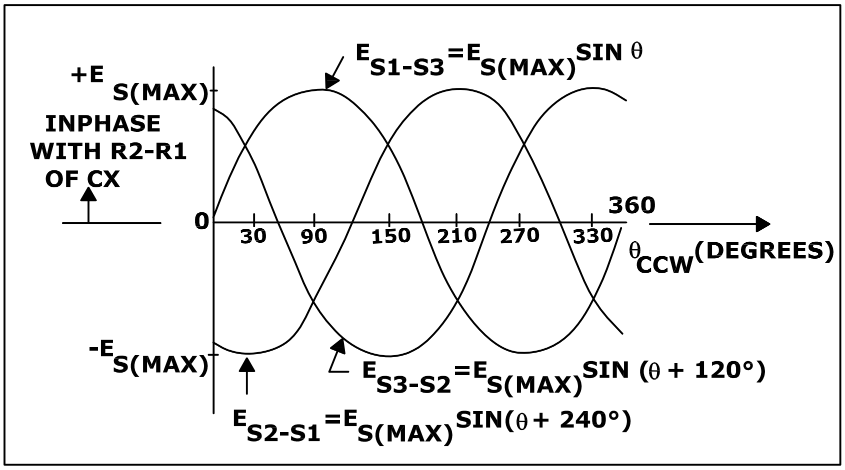


Figure 4-2. Standard Synchro Control Transmitter (CX) Outputs

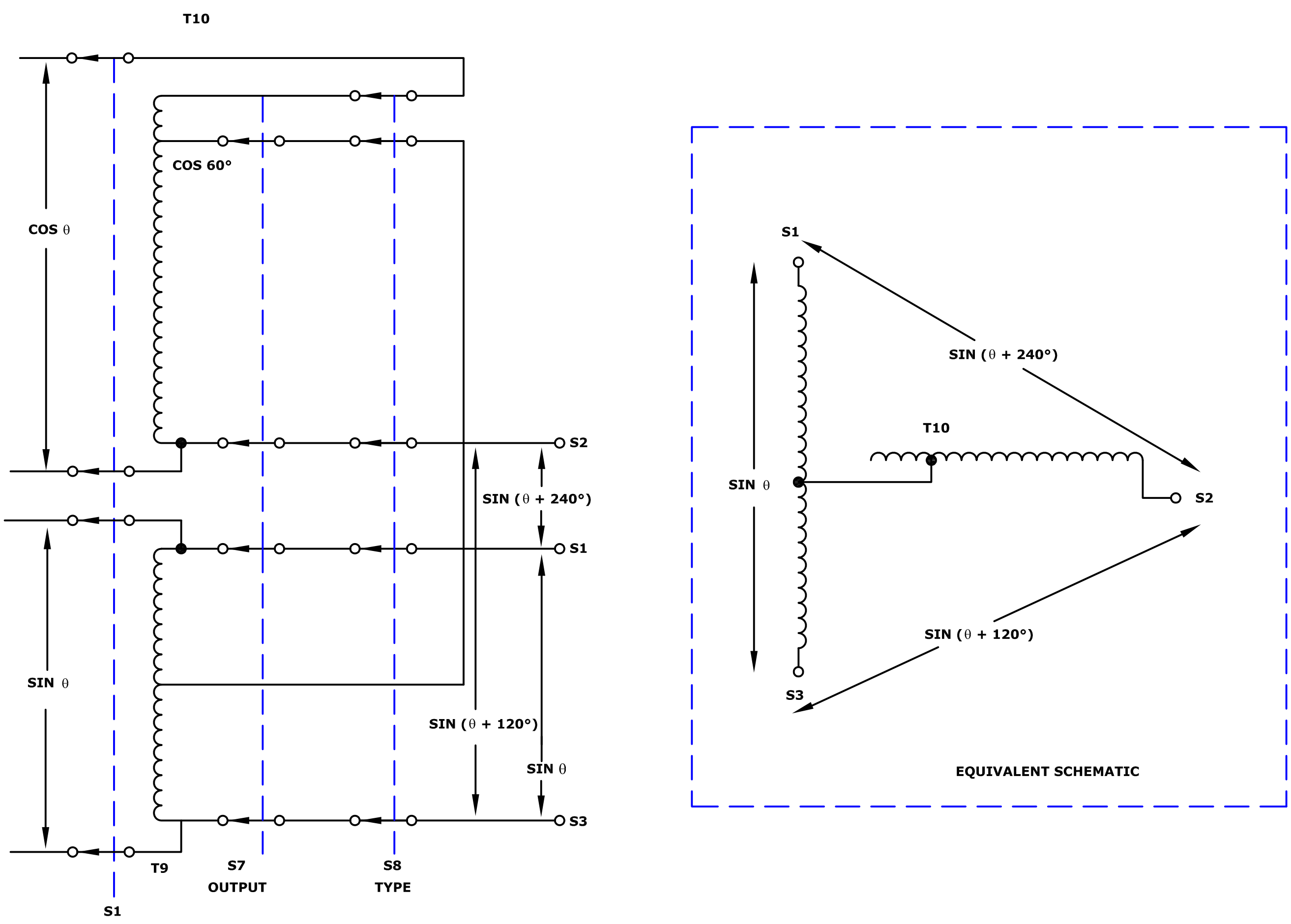
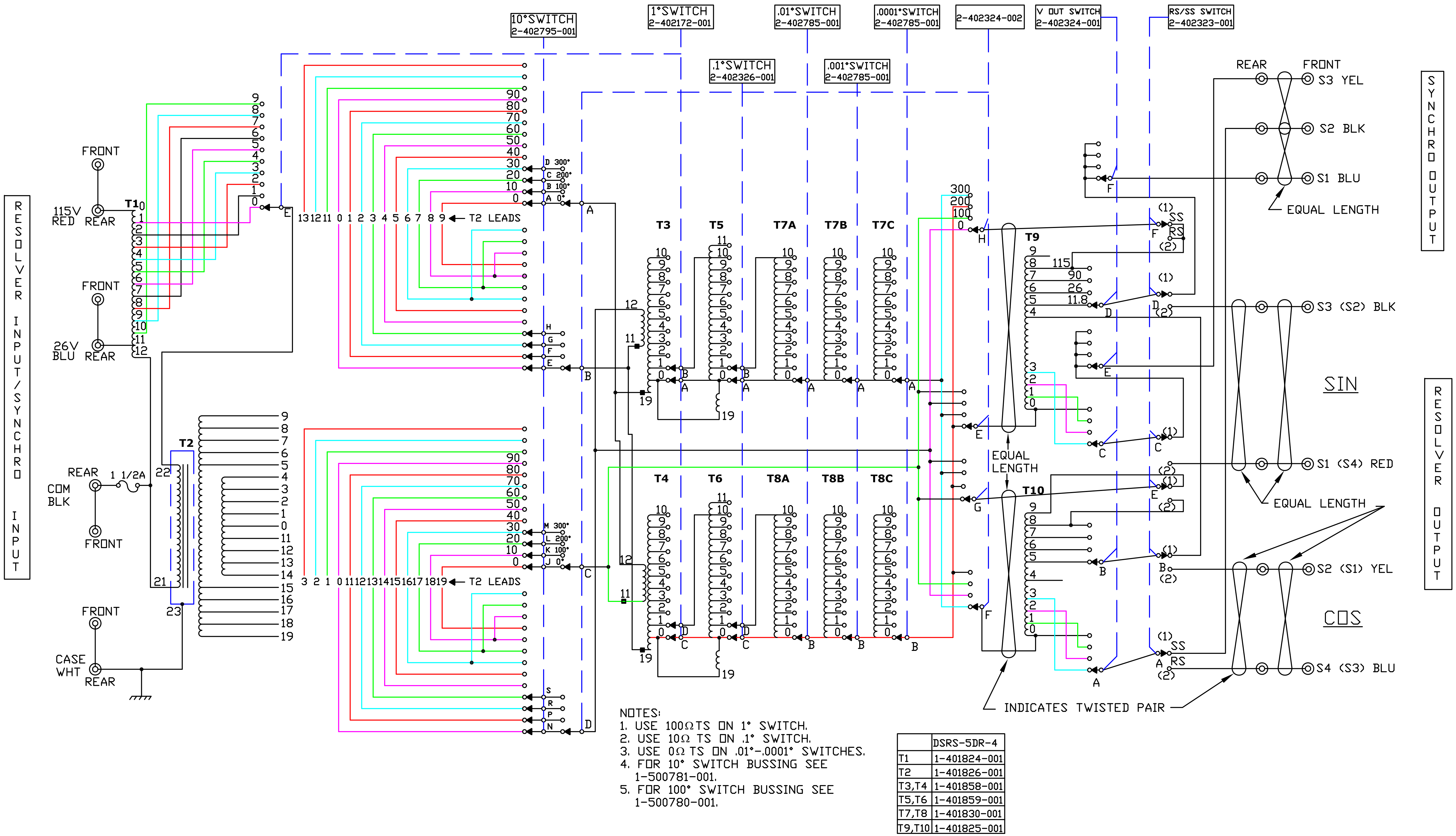


Figure 4-3. Synchro Mode, Simplified Diagram



NOTES:
1. USE 100Ω TS ON 1° SWITCH.
2. USE 10Ω TS ON .1° SWITCH.
3. USE 0Ω TS ON .01°-.0001° SWITCHES.
4. FOR 10° SWITCH BUSSING SEE 1-500781-001.
5. FOR 100° SWITCH BUSSING SEE 1-500780-001.

	DSRS-5DR-4
T1	1-401824-001
T2	1-401826-001
T3,T4	1-401858-001
T5,T6	1-401859-001
T7,T8	1-401830-001
T9,T10	1-401825-001

Figure 4-4. Model DSRS-5DA Schematic Diagram

SECTION V
MAINTENANCE

5.1 GENERAL

Since the standards are passive devices, a minimum of maintenance is required. With the exception of cleaning switch contacts, no maintenance on a regularly scheduled basis is required. Moving parts are lubricated at the factory and should require no further lubrication.

5.2 SWITCH SERVICING

During calibration intervals, clean switch contacts with a good grade of solvent such as alcohol or acetone. Relubricate contacts with a thin layer of vaseline.

5.3 REPAIRS

If any repairs are made on the unit or if any parts are replaced, check the accuracy of the unit as outlined below. If any transformer problems are encountered, it is recommended that the unit be returned to the factory for overhaul and recalibration.

5.4 CALIBRATION

The accuracy of the standard should be maintained for a period of not less than three years, provided that the unit is kept in a normal laboratory environment, has clean low-resistance contacts and does not suffer injury or insulation damage. Under these conditions, the unit should only require calibration every three years. Under more severe conditions, the calibration period must be shortened. Note: Full calibration is to be done with 115V rms, 400 Hz reference input, and 115 V E_s (MAX) output. The remaining outputs shall be tested on a random basis.

5.5 TEST EQUIPMENT

To test the accuracy of the unit, the following test equipment (or equivalent) is required:

a. Phase Angle Voltmeter, Tegam Model PAV-4B or 4C.

b. Ratio Standard, Tegam Model 1011A.

c. Audio Oscillator, 20Hz to 20k Hz

d. Power Amplifier, 200W

e. Digital Voltmeter

5.6 ANGULAR ACCURACY, RESOLVER MODE

To test the angular accuracy of the resolver standard, proceed as follows

a. Connect unit into test setup as shown in Figure 5-1.

NOTE

> Connect the ratio standard directly to the output terminals of the resolver standard to eliminate errors resulting from voltage drops in the interconnecting leads.

b. Adjust Phase Angle Voltmeter to measure in-phase voltage
c. Set resolver standard to 0°.
d. Adjust ratio standard as required to obtain a null on Phase Angle Voltmeter.
e. The ratio standard shall indicate an output ratio (A theoretical) of 0.000000 within the limits set by the A column of Table 5-1.
f. Repeat test at every 5°increment between 0° and 360°. Refer to Table 5-1 for the required output ratio and tolerances,

NOTE

The effective output impedance unbalance of the standard may be readily checked by applying a BALANCED load to the output and measuring A. When testing with an inductive load, it is recommended that non-ferromagnetic inductors (GR Type 1482 or equivalent) be used to prevent output voltage variations from changing the inductance of the load.

g. Repeat test at the decade increments. Refer to Table 5-2 for the required ratios and tolerances.

5.7 ANGULAR ACCURACY, SYNCHRO MODE

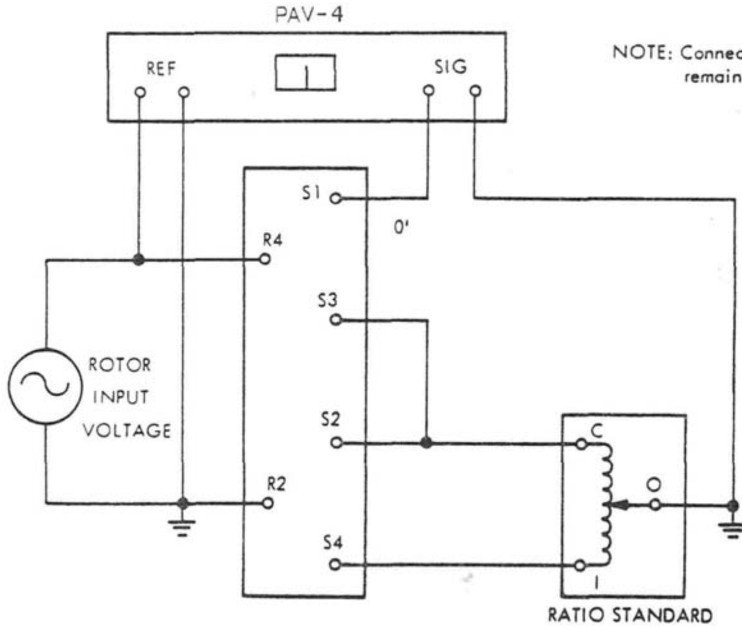
To test the angular accuracy of the synchro standard, proceed as follows

a. Connect unit into test setup as shown in Figure 5-2.
b. Adjust phase angle voltmeter to measure in-phase voltage.
c. Set the synchro standard to 0° .
d. Adjust ratio standard as required to obtain a null on the phase angle voltmeter.
e. The ratio standard shall indicate an output ratio (A theoretical) of 0.000000 within the limits set by △ A column of Table 5-3.
f. Repeat test at the increments listed in Table 5-3.

5.8 VOLTAGE OUTPUT TEST

This test is performed in the Resolver mode without load using the following procedure:

a. See Figure 5-3 for equipment setup.
b. Switch the DSRS-5DA to the RESOLVER mode of operation.
c. Set the DSRS-5DA DEGREE controls to degree settings shown in Table 5-4. (Other degree settings may be added to Table 5-4 including appropriate trigometric output voltages expected.)
d. Adjust the 400 Hz Power Source input voltage to exactly 115 V ac.
e. Take DVM measurements at the Resolver COS θ and SIN θ output terminals (S4, S2 and S1, S3 respectively) for each position of the E_S MAX OUTPUT switch and for the degree settings shown in Table 5-4. The COS θ and SIN θ output voltages should match the voltages as shown in Table 5-4. Differences are typically less than 1%.
f. Steps “a” through “e” may be repeated using 26 V to the 26 V R4, R2 input terminals.



NOTE: Connected for measurements between 0° and 40°. For remaining measurements, connect as follows:

θ	0'	C	I	C
0° to 40°	S1	S2	S4	S3
45° to 85°	S4	S2	S1	S3
90° to 130°	S2	S3	S1	S4
135° to 175°	S1	S3	S2	S4
180° to 220°	S3	S4	S2	S1
225° to 265°	S2	S4	S3	S1
270° to 310°	S4	S1	S3	S2
315° to 355°	S3	S1	S4	S2

Figure 5-1. Angular Accuracy Test Setup, Resolver Mode

TABLE 5-1. ANGULAR ACCURACY, RESOLVER MODE

θ								$A_{theoretical}$	$\Delta A_{(ppm)}$
0		90		180		270		0.000000	9
5	85	95	175	185	265	275	355	0.087489	9
10	80	100	170	190	260	280	350	0.176327	10
15	75	105	165	195	255	285	345	0.267949	10
20	70	110	160	200	250	290	340	0.363970	11
25	65	115	155	205	245	295	335	0.466308	11
30	60	120	150	210	240	300	330	0.577350	13
35	55	125	145	215	235	305	325	0.700208	14
40	50	130	140	220	230	310	320	0.839100	16
	45		135		225		315	1.000000	19

TABLE 5-2. ANGULAR ACCURACY, DECADE INCREMENTS, RESOLVER MODE

ANGULAR SETTING	THEORETICAL RATIO	MAXIMUM DEVIATION±
0.001	0.0000175	0.0000097
0.002	0.0000349	0.0000097
0.003	0.0000524	0.0000097
0.004	0.0000698	0.0000097
0.005	0.0000873	0.0000097
0.006	0.0001047	0.0000097
0.007	0.0001222	0.0000097
0.008	0.0001396	0.0000097
0.009	0.0001571	0.0000097
0.01	0.0001745	0.0000097
0.02	0.0003491	0.0000097
0.03	0.0005236	0.0000097
0.04	0.0006981	0.0000097
0.05	0.0008727	0.0000097
0.06	0.0010472	0.0000097
0.07	0.0012217	0.0000097
0.08	0.0013963	0.0000097
0.09	0.0015708	0.0000097

ANGULAR SETTING	THEORETICAL RATIO	MAXIMUM DEVIATION±
0.1	0.0017453	0.0000097
0.2	0.0034907	0.0000097
0.3	0.0052360	0.0000097
0.4	0.0069814	0.0000097
0.5	0.0087269	0.0000097
0.6	0.0104724	0.0000097
0.7	0.0122179	0.0000097
0.8	0.0139635	0.0000097
0.9	0.0157093	0.0000097
1	0.0174551	0.0000097
2	0.0349208	0.0000097
3	0.0524078	0.0000097
4	0.0699268	0.0000098
5	0.0874887	0.0000098
6	0.1051042	0.0000098
7	0.1227846	0.0000098
8	0.1405408	0.0000100
9	0.1583844	0.0000100

TABLE 5-3. ANGULAR ACCURACY, SYNCHRO MODE

θ	$A_{theoretical}$	$\triangle A_{(ppm)}$
0	0.000000	11
135	0.267949	9
210	0.500000	8
345	0.732051	9

Table 5-4. E_S (MAX) Switch Position Versus Outputs

115 V INPUT	OUTPUT VOLTS						
E_S(MAX) OUTPUT (SW. POSITON)	COS θ VOLTAGE (at terminals S4 and S2) 0°	45°	90°	135°	180°	225°	270°
11.8 V	11.8	8.34	0	8.34	11.8	8.34	0
26 V	26.0	18.38	0	18.38	26.0	18.38	0
90 V	90.0	63.64	0	63.64	90.0	63.64	0
115 V	115.0	81.317	0	81.317	115.0	81.317	0
E_S(MAX) OUTPUT (SW. POSITON)	SIN θ VOLTAGE (at terminals S3 and S1) 0°	45°	90°	135°	180°	225°	270°
11.8 V	0	8.34	11.8	8.34	0	8.34	11.8
26 V	0	18.38	26.0	18.38	0	18.38	26.0
90 V	0	63.64	90.0	63.64	0	63.64	90.0
115 V	0	81.317	115.0	81.317	0	81.317	115.0

QUADRANT	SWITCH POSITION
0° - 55°	2
60° - 115°	1
120° - 175°	3
180° - 235°	2
240° - 295°	1
300° - 355°	3

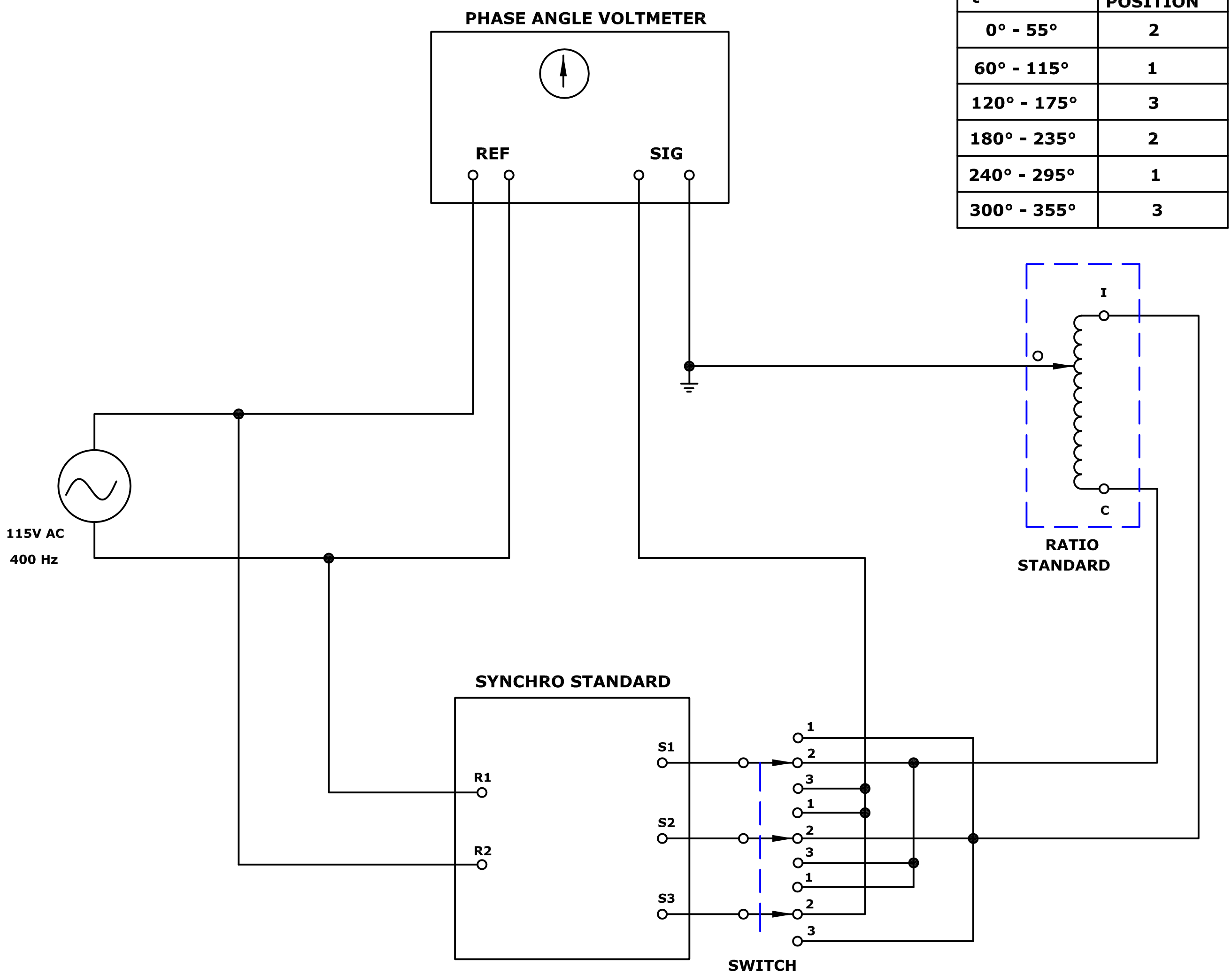


Figure 5-2. Angular Accuracy Test Setup, Synchro Mode

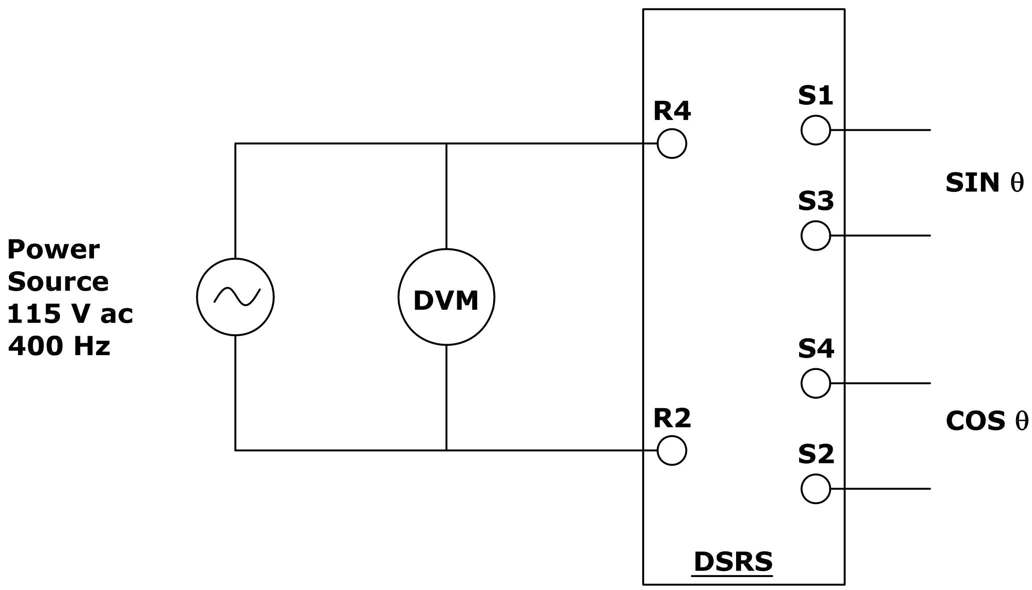


Figure 5-3. Output Voltage Test Setup, Resolver Mode